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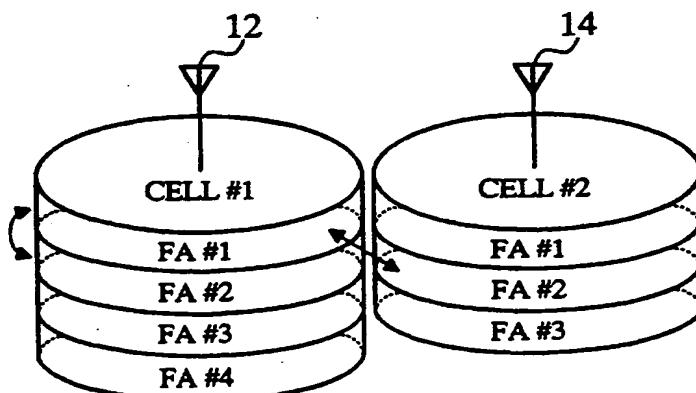
## Best Available Copy

(54) Abstract Title

Semi-soft handoff using multiple common frequencies

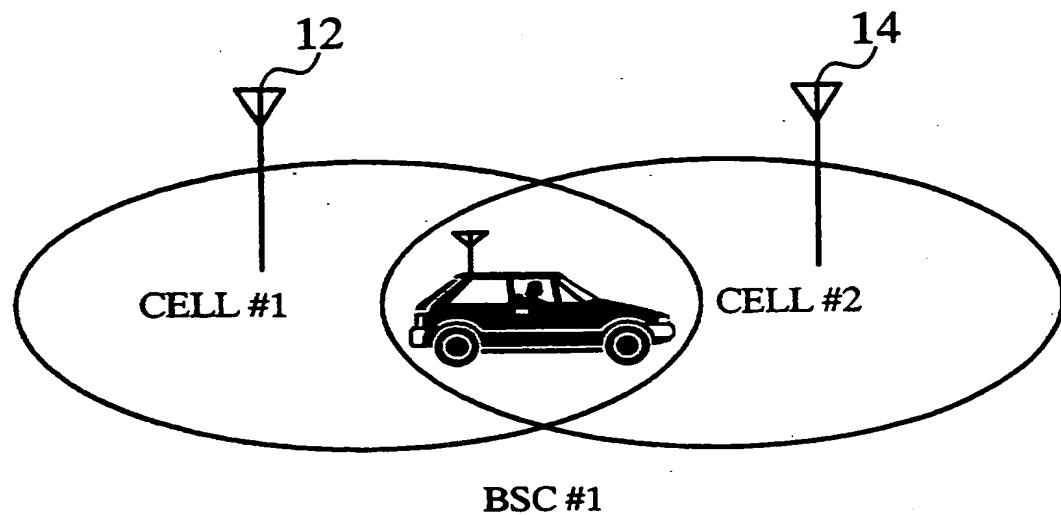
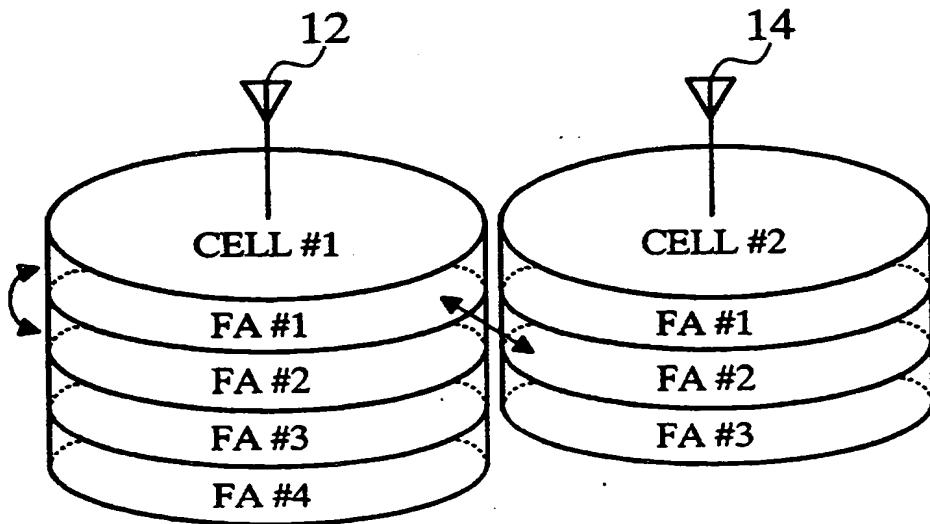
(57) Method and apparatus for semi-soft handoff in a communication system having a first base station 12 and a destination base station 14 which use multiple common frequencies FA1-FA3 and a multiple frequency channel. In order to guarantee continuation of a call when a mobile station moves into a new cell, a base station examines all adjacent cells' frequency assignment conditions and designates the frequencies that all cells have in common as the common frequencies FA1-FA3. The base station detects the common frequency having the lowest load and when handoff is requested, executes an intra-cell, inter-frequency hard handoff to this common frequency and an inter-cell soft handoff to the destination cell 14 using this common frequency. The base station may manage traffic within the common frequencies so that the traffic loads are substantially uniform with hard handoff being forced when a common frequency is overloaded. Further, an idle mobile on a common frequency may be re-assigned to a non-common frequency paging channel preventing new traffic being assigned to the common frequency. The system may employ a CDMA technique.

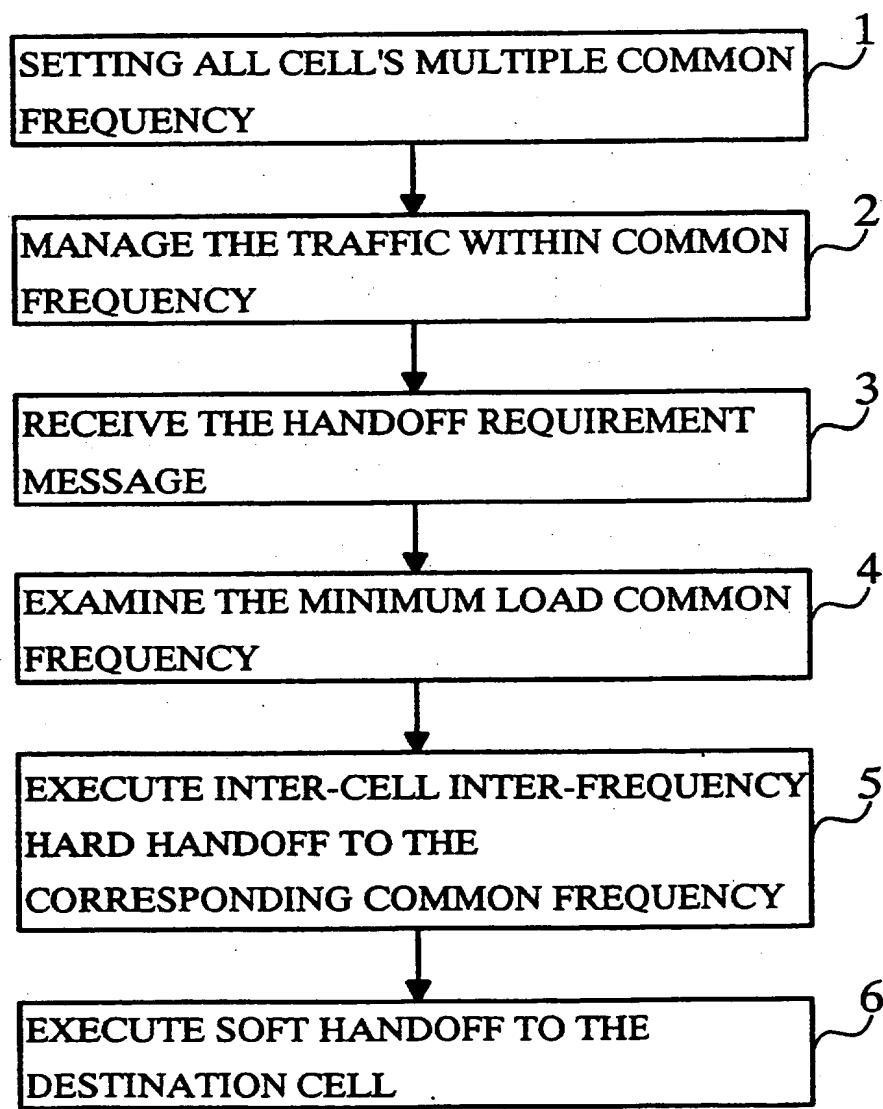
**FIG. 2**



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

**FIG. 1****FIG. 2**

**FIG. 3**

A SEMI-SOFT HANDOFF METHOD USING  
MULTIPLE COMMON FREQUENCIES

5        This invention relates to a semi-soft handoff method and system that uses multiple common frequencies, and more particularly, to a system and method of executing inter-cell inter-frequency assignments with semi-soft handoffs in mobile communication systems employing a Code Division Multiple Access (CDMA) technique.

10      A Personal Communications Services (PCS) and/or CDMA cellular system typically include a Base station Transceiver Subsystem (BTS), a Base Station Controller (BSC), a Base Station Manager System that manages the operation of many BSCs, a Switching system and a Location Registration System. Each base station transceiver subsystem usually manages one cell.

15      As a wireless telephone (mobile station or unit) moves between various coverage areas, communication transmission difficulties should be minimised, and when the mobile station is idle, the mobile station must regularly re-register according to the status of various parameters. When a call 20 is in progress, the mobile station, the base station and the switching station manage the communication between the mobile station and the base station to maintain an acceptable radio link efficiency.

25      In a CDMA and a wide-band CDMA system, one mobile station can simultaneously receive signals from two or more base stations. Therefore, the CDMA and the wide-band CDMA system can process a handoff from one base station to another base station or from one antenna area to another area within 30 one base station.

35      As for the CDMA cellular and the PCS system, to guarantee the call's continuance, various forms of handoffs are offered. These various forms of handoffs can have 40 efficiency differences with respect to their reliability

regarding a call's continuance and the system load which follows from the method of handoff and from the content of the call.

5        As is known to those skilled in the art, the handoff method is classified into mainly soft handoffs and hard handoffs. Soft handoffs are classified into inter-cell soft handoffs, inter-BSC soft handoffs and inter-sector soft handoffs. In particular, the inter-sector handoff is often  
10      called softer handoff. Hard handoffs are classified into inter-MSC (mobile station switching center) hard handoffs, inter-frequency assignment hard handoffs and inter-frame offset hard handoffs.

15      In addition, there is an inter-cell inter-frequency handoff in the CDMA network which is employed when the serviceable frequency channel's number does not accord with adjacent cells. With respect to this type of system, the inter-cell inter-frequency handoff is categorised into an  
20      inter-cell inter-frequency hard handoff that uses a pilot generator and a semi-soft handoff that uses a common frequency.

25      Although the inter-cell inter-frequency hard handoff, which uses the pilot generator, requires inter-cell handoff, it is also a method of directly transferring to another frequency within a destination cell in the case where the frequency used in the present call cannot receive the service within the destination cell into which the mobile station is  
30      be moved. For additional hardware, like the pilot generator, etc that must be setup in the system, space is needed within the system and must be provided with the necessary power and signal/power etc interface(s). Furthermore, for one pilot generator, there is a need for a channel card, a sector interface card, a transceiver module and a high power amplifier etc. If the pilot generator were miniaturised for use in external equipment, it would become much more difficult to provide an interface between the external pilot

generator and the inter-cell system's interface. In this case, to combine the pilot generator's final output to the system's output, additional modules like RF power couplers, etc are needed. As these additional modules add expense to 5 the entire system, a system redesign considering such changes is required. To compensate for the additional power loss, the system output level must also be increased. Limitations in the performance and in the development of a miniaturised mobile system are brought about by these problems.

10

The Semi-Soft Handoff, which uses a common frequency, processes the handoff by software means. It uses a primary channel with the common frequency when the adjacent inter-cell frequency assignment is different. However, unlike the 15 inter-cell inter-frequency hard handoff which uses the pilot generator to verify the presence of an adjacent base station, the semi-soft handoff method determines the handoff point based only on the weakening of the present cell's pilot signal power. However, because the handoff method does not 20 require additional hardware, it is beneficial with regard to system price, use of space and facility maintenance repairs.

With a semi-soft handoff method, because the inter-frequency hard handoff within the cell occurs toward the 25 common frequency, the decisive parameter required for the handoff is the amount of the common frequency's load. If the amount of the common frequency's load is excessive, additional requests for inter-frequency hard handoffs within the cell cannot be processed. Also, the assignment of a new 30 call to the common frequency and a soft handoff from the adjacent base station cannot be processed. Therefore, whether the common frequency will be overloaded can be determined by comparing the hard handoff call's load occurring within the cell and the common frequency processing 35 function amount for the entire call processing system.

Therefore, a need exists for an improved handoff method which employs multiple common frequencies to address problems

occurring due to common frequency overload.

The present invention was devised to solve problems in the semi-soft handoff method. The object of the invention is  
5 to offer a semi-soft handoff method that uses multiple common frequencies.

Accordingly, a first aspect of the present invention provides a semi-soft handoff method of a mobile station  
10 within a communication system having a first base station and a destination base station which use multiple common frequencies and a multiple frequency channel, the method comprising the steps of: designating frequencies as common frequencies; selecting the common frequency with a lowest  
15 load from the common frequencies; and executing a hand-off using the selected common frequency.

A second aspect of the present invention provides a semi-soft handoff system of a mobile station within a  
20 communication system having a first base station and a destination base station which use multiple common frequencies and a multiple frequency channel, the system comprising means for designating frequencies as common frequencies; means for selecting the common frequency with a lowest load from the common frequencies; and means for  
25 executing a hand-off using the selected common frequency.

An embodiment provides a semi-soft handoff method, using multiple common frequencies. A base station makes use of a  
30 multiple frequency channel. When a mobile station moves inter-cell, and the service on the frequency that processes a present sector within a destination cell to be moved to is not offered, to guarantee the call's continuance, the base station examines all adjacent cells' frequency assignment  
35 conditions and detects the frequencies that all cells have in common and designates the detected frequencies as the common frequencies of all cells'. The traffic is managed within the common frequency. When a handoff request message is received

by a base station, the base station detects a common frequency with a lowest load from among the common frequencies. The base station executes an intra-cell inter-frequency hard handoff to the common frequency with the  
5 lowest load, and an inter-cell soft handoff to the destination cell by using the common frequency. An inter-cell inter-frequency hard handoff is executed to a corresponding common frequency. A soft handoff is executed to the destination cell by using the common frequency  
10 determined by the examination of minimum load.

In the present invention, it is preferable that each base station individually executes inter-cell inter-frequency handoffs using multiple common frequencies, that the inter-cell inter-frequency handoff is determined based on the power of the pilot signal receiving the present service when the hard handoff is executed. It is also preferable that the number of the common frequencies is set at the lowest among frequencies assigned to each cell. When a common frequency  
15 is overloaded, calls of the overloaded common frequency move to another frequency by forcing a hard handoff. It is further preferable that the base station designates a paging channel of an idle mobile station within the common frequency as a noncommon frequency so as to avoid new traffic from  
20 being assigned to the common frequency. When the idle mobile station tries to form a traffic channel, the base station assigns traffic for the mobile station to a traffic channel in the noncommon frequency. The base station manages the load of traffic for each common frequency for traffic  
25 uniformity. Accordingly, the base station assigns traffic from new calls to a common frequency with the lowest traffic load. A function is provided to set up a call by assigning the traffic channel to a different frequency, not to the corresponding mobile station's frequency range when setting a  
30 new call. The sector is set to another frequency by designating a CDMA frequency's description to an applicable frequency, which is among the descriptions of the paging channel CDMA assigned messages.  
35

In one preferred mode, in accordance with the present invention, the semi-soft handoff method, in the instance a base station makes use of multiple frequency channel, a mobile station moves inter-cell and service on a frequency that processes the present call within the destination cell to be moved to is not offered, to guarantee the call's continuance, the base station examines all adjacent cells' frequency assignment conditions and detects frequencies that all cells have commonly and designates the detected frequencies as all cells' common frequency. Furthermore, the base station manages the traffic within the multiple common frequencies. After receiving a handoff request message, the base station detects a common frequency with a minimum load among the common frequencies. The base station executes an intra-cell inter-frequency hard handoff to the common frequency with the lowest load and an inter-cell soft handoff to the destination cell by using the common frequency. Next, the base station executes an inter-cell inter-frequency hard handoff to the corresponding common frequency and soft handoff to the destination cell by using the common frequency.

Embodiments of the present invention will now be provided, by way of example only, with reference to the accompanying drawings in which:

figure 1 illustrates an inter-cell soft handoff;

figure 2 is a schematic illustrating an inter-frequency hard handoff; and

figure 3 is a flow/block diagram showing steps for an inter-cell inter-frequency handoff method and system in accordance with the present invention.

A semi-soft handoff method and system which uses multiple common frequencies is described. The invention

executes inter-frequency hard handoffs within a cell for inter-cell inter-frequency handoffs. In one aspect of the invention, the use of multiple common frequencies is employed to reduce overloading of the or any particular common frequency. In distinguishing from the prior art, which uses only an initial FA1 channel as the common frequency, the invention checks multiple cell frequency assignment conditions and uses as the common frequency in each cell, the frequency which has the lowest number of frequency assignments.

Referring to figure 1, a mobile station 10 is shown moving between cell #1 and cell #2 (destination cell). Each cell is maintained by a base station 12 and 14. When mobile station 10 reaches the destination cell a handoff occurs and service is provided by cell #2 instead of cell #1.

Referring to figure 2, each cell operates at a common frequency. Multiple common frequencies (on channels FA) are provided such that handoff is more efficiently performed and overload of a given frequency channel is less likely.

Referring to figure 3, a semi-soft handoff method, using multiple common frequencies, includes step 1 for detecting multiple frequencies that all cells have in common and designating the detected multiple frequencies as the common frequencies of all cells'. Step 2 manages the traffic using the designated common frequencies. Step 3 receives the handoff requirement message from the mobile station. Step 4 examines all of an adjacent cells' frequency assignment conditions and determines the common frequency with the minimum load. Step 5 executes intra-cell inter-frequency hard handoff to the determined common frequency having the minimum load, and step 6 executes a soft handoff to the destination cell by using the common frequency determined in step 4 to have the minimum load.

It is preferable to maintain the traffic load of the

common frequencies within the cell where the handoff occurs such that they are substantially equal. This invention selects the lowest frequency assignment number's value as the common frequency number by referring to its own cell's and an 5 adjacent cell's frequency assignment conditions.

Referring again to figure 2, in an illustrative example of the present invention, if cell #2, which has 3 FAs, contains the lowest frequency assignment numbers from among 10 the adjacent cells, then FA1-FA3 may be designated as the common frequencies. The difference in adjacent inter-cell's frequency assignment is checked to ensure that not more than 2 frequency assignments are employed simultaneously. For example, when n number of frequencies are assigned to a cell, 15 and n+1 number of frequencies are assigned to another cell, the common frequency can process a load of  $n/(n+1)$ , at maximum.

Here, the paging channel is one of CDMA overhead 20 channels added to process other commands while a mobile station is on or idle.

To maintain the multiple common frequencies traffic load uniformity, each frequency channel's traffic load must be 25 managed while hard handoffing the new call to the frequency of the lowest load. Furthermore, to avoid new traffic from being assigned to the common frequency, the base station reassigned new traffic of the idle mobile station to a noncommon frequency. The idle mobile station is reassigned 30 to a paging channel of the noncommon frequency, or when the idle mobile station tries to establish a traffic channel, the traffic is assigned to the noncommon frequency. Then, when the traffic channel for the idle mobile station on the common frequency is set, it is set to the noncommon frequency, not 35 to the common frequency.

As an additional safety measure, the ability to handoff the common frequency's traffic to the noncommon frequency is

added in case where the common frequency's load is exceeded. This addition solves common frequency overload problems.

The system in accordance with the invention manages, 5 initially, the condition of all adjacent cells' frequency assignments and sets all cells' common frequencies to the frequency of lowest number of assignments.

By evaluating whether the present mobile station is idle 10 on the common frequency, the base station may either reassign the mobile station to a paging channel on the noncommon frequency or, when setting the traffic channel, assign the traffic to the traffic channel on the noncommon frequency.

15 Furthermore, it is evaluated whether all common frequency loads are exceeded and, if the loads are exceeded, the traffic on the common frequency is handed off to the noncommon frequency.

20 Through the above processes, when receiving a handoff request message, a base station determines whether or not the traffic of the common frequencies is substantially uniform, and determines the common frequency with the lowest load. After the common frequency with the lowest load is 25 determined, traffic is assigned to this common frequency through the inter-frequency hard handoff in the cell. Next, by executing the soft handoff to the destination cell using the common frequency, the inter-cell inter-frequency handoff is completed.

30

Advantageously, the present invention needs no additional hardware, the algorithm is simple and reliability is high.

35

An overload danger condition for a specific frequency range is reduced considerably by maintaining multiple common frequencies. Even inappropriate judgments or in unavoidable cases, when setting the call, the problem of traffic

concentration to the common frequency is prevented through traffic channel designation, and the distribution of the traffic in the overload frequency bandwidth to another frequency is performed.

5

Having described preferred embodiments for a novel a semi-soft handoff method that uses multiple common frequency (which are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by 10 persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention disclosed which are within the scope and spirit of the invention as outlined by the appended claims. Having thus described the invention 15 with the details and particularly required by the patent laws, what is claimed and desired protected by Letters Patent is set forth in the appended claims.

**CLAIMS**

1. A semi-soft handoff method of a mobile station within a communication system having a first base station and a destination base station which use multiple common frequencies and a multiple frequency channel, the method comprising the steps of: designating frequencies as common frequencies; selecting the common frequency with a lowest load from the common frequencies; and executing a hand-off using the selected common frequency.  
5
2. A semi-soft handoff method as claimed in claim 1, wherein the step of executing a handoff comprises the step of executing intra-cell inter-frequency hard hand-off to the lowest load common frequency.  
10
3. A semi-soft handoff method as claimed in either of claim 2, wherein the step of executing inter-cell inter-frequency hard hand-off includes the step of determining inter-frequency handoffs based on power of a pilot signal receiving a present service.  
15
4. A semi-soft handoff method as claimed in any preceding claim, wherein the step of executing a handoff comprises the step of executing a soft handoff to the destination cell using the lowest load common frequency.  
20
- 25 5. A semi-soft handoff method as claimed in any preceding claim, wherein said base station individually uses multiple common frequencies to execute inter-cell inter-frequency handoffs.
6. A semi-soft handoff method as claimed in any preceding claim, wherein the selected common frequency, selected by examining adjacent cells' frequency assignment conditions, is a frequency associated with a lowest assignment number of the cells  
30

7. A semi-soft handoff method as claimed in any preceding claim, further comprising the step of managing traffic, preferably by the first station, within the common frequencies.
- 5 8. A semi-soft handoff method as claimed in claim 7, wherein the step of managing traffic includes the step of forcing a hard handoff, when the common frequency is overloaded, of a call on the common frequency channel for which the overload occurred to another frequency channel having a lower load than that of the overloaded common frequency.
- 10 9. A semi-soft handoff method as claimed in any preceding claim, further comprising the steps of:
  - 15 reassigning an idle mobile station on a common frequency to a paging channel with the idle state in a noncommon frequency band; and
  - preventing new traffic from being assigned to the common frequency
10. A semi-soft handoff method as claimed in any preceding claim, further comprising the step of assigning new traffic to a noncommon traffic channel when an idle mobile station's traffic channel is created using the common frequency.
- 20 11. A semi-soft handoff method as claimed in any preceding claim, wherein each multiple common frequency has a traffic load and the method further comprising the step of managing the traffic loads to make the traffic loads substantially uniform.
- 25 12. A semi-soft handoff method as claimed in any preceding claim, further comprising the step of changing the channel of a new call from one of the multiple common frequency channels to a new channel by setting the channel to a frequency channel with the lowest traffic

load, each frequency channel's traffic load being managed.

13. A semi-soft handoff as claimed in any preceding claim, further comprising the step of setting a new call by assigning a traffic channel to a frequency other than a corresponding mobile station's frequency band.

5 14. A semi-soft handoff method as claimed in any preceding claim, further comprising the step of setting a call to another frequency by designating a corresponding frequency to a CDMA frequency's contents based on contents of CDMA assigning messages for paging channels.

10 15. A semi-soft handoff system of a mobile station within a communication system having a first base station and a destination base station which use multiple common frequencies and a multiple frequency channel, the system comprising: means for designating frequencies as common frequencies; means for selecting the common frequency with a lowest load from the common frequencies; and means for executing a hand-off using the selected common frequency.

15 16. A semi-soft handoff system as claimed in claim 15, wherein the means for executing a handoff comprises means for executing intra-cell inter-frequency hard hand-off to the lowest load common frequency.

20 17. A semi-soft handoff system as claimed in either of claim 16, wherein the means for executing inter-cell inter-frequency hard hand-off includes means for determining inter-frequency handoffs based on power of a pilot signal receiving a present service.

25 18. A semi-soft handoff system as claimed in any of claims 15 to 17, wherein the means for executing a handoff comprises means for executing a soft handoff to the destination cell using the lowest load common frequency.

19. A semi-soft handoff system as claimed in any of claims 15 to 18, wherein the first base station individually uses multiple common frequencies to execute inter-cell inter-frequency handoffs.
- 5    20. A semi-soft handoff system as claimed in any of claims 15 to 19, wherein the selected common frequency, selected by examining adjacent cells' frequency assignment conditions, is a frequency associated with a lowest assignment number of the cells
- 10    21. A semi-soft handoff system as claimed in any of claims 15 to 20, further comprising means for managing traffic, preferably by the first base station, within the common frequencies.
- 15    22. A semi-soft handoff means for as claimed in claim 21, wherein the means for managing traffic includes means for forcing a hard handoff, when the common frequency is overloaded, of a call on the common frequency channel for which the overload occurred to another frequency channel having a lower load than that of the overloaded common frequency.
- 20    23. A semi-soft handoff system as claimed in any of claims 15 to 22, further comprising  
means for reassigning an idle mobile station on a common frequency to a paging channel with the idle state in a noncommon frequency band; and  
means for preventing new traffic from being assigned to the common frequency
- 25    24. A semi-soft handoff system as claimed in any of claims 15 to 23, further comprising means for assigning new traffic to a noncommon traffic channel when an idle mobile station's traffic channel is created using the common frequency.

25. A semi-soft handoff system as claimed in any of claims  
15 to 24, wherein each multiple common frequency has a  
traffic load and the system further comprising means for  
managing traffic load to make the traffic loads  
substantially uniform.

5

26. A semi-soft handoff system as claimed in any of claims  
15 to 25, further comprising means for changing the  
channel of a new call from one of the multiple common  
frequency channels to a new channel by setting the  
10 channel to a frequency channel with the lowest traffic  
load, each frequency channel's traffic load being  
managed.

15

27. A semi-soft handoff system as claimed in any of claims  
15 to 26, further comprising means for setting a new  
call by assigning a traffic channel to a frequency other  
than a corresponding mobile station's frequency band.

20

28. A semi-soft handoff system as claimed in any of claims  
15 to 27, further comprising means for setting a call to  
another frequency by designating a corresponding  
frequency to a CDMA frequency's contents based on  
contents of CDMA assigning messages for paging channels.

25

29. A semi-soft hand-off method substantially as described  
herein with reference to and/or as illustrated in the  
accompanying drawings.

30. A semi-soft hand-off system substantially as described  
herein with reference to and/or as illustrated in the  
accompanying drawings.



Application No: GB 9818031.8  
Claims searched: 1-28

Examiner: Anita Keogh  
Date of search: 21 December 1998

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4L (LDSHE, LDSHS, LDSHX, LDSW)

Int Cl (Ed.6): H04Q 7/38

Other: Online: WPI

**Documents considered to be relevant:**

Categor y	Identity of document and relevant passage	Relevant to claims
A	GB 2321166 A (ERICSSON) see abstract	
A	EP 0876005 A2 (NEC) see abstract and figures	
X	EP 0710044 A2 (ALCATEL) see abstract and figure 1	1, 15 at least
A	EP 0535714 A1 (ERICSSON) see abstract	

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